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(54) DIFFERENTIAL PRESSURE PLASTICS SHEET FORMING MACHINE

(71) We, BROWN MACHINE COMPANY OF MICHIGAN, INC., a corporation organised under the laws of the State of Michigan, United States of America, of 330 North Ross Street, Beaverton, Michigan, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement: —

This invention relates to machines for forming articles such as containers in thermoplastic, synthetic plastics sheets and more particularly to a partible or segmental mold mechanism which is suitable for thermoforming containers having portions of increased girth between their ends.

An object of the invention is to provide simple and reliable partible mold mechanism, capable of differential pressure forming diversely shaped containers in a deformable plastics sheet, which is operable automatically to move from closed to open position to release the parts formed when the female mold mechanism is withdrawn from the plastics sheet after formation of the parts therein.

A further object of the invention is to provide a differential pressure thermoforming machine having opposed molds movable toward and away from a plastics web wherein the partible mold segments operate to strip the web after the articles are formed therein.

According to the present invention, a differential pressure forming machine for forming articles such as containers comprises female mold assembly means; cavity forming female mold means carried by said female mold assembly means; axially opposed mold means; means for advancing a sheet of hot deformable plastic between said female mold means and opposed mold means; means mounting said female mold assembly means and female mold means for relative axial travel; means for moving said female mold assembly means and thereby said female mold means toward said opposed mold means; means for producing a differential pressure on opposite sides of said plastics sheet and causing a portion of said sheet to be formed to the shape of said female mold means; means for moving said female mold assembly means away from said opposed mold means; and means holding said female mold means in engagement with said sheet, when the female mold assembly means is withdrawn following formation of the shape in said female mold means, for a predetermined interval to operate to strip the sheet from the withdrawing female mold assembly means.

The invention is illustrated in the accompanying drawings, in which:

Figure 1 is a fragmentary, partly sectional, perspective, elevational view of a differential pressure forming machine which incorporates the invention;

Figure 2 is a transverse sectional elevational view taken on the line 2—2 of Figure 1;

Figure 3 is a greatly enlarged, fragmentary, perspective, elevational view of one of the segmental cavity forming dies or molds which are incorporated in the upper mold assembly;

Figure 4 is a fragmentary, sectional, elevational view of the upper mold assembly on an enlarged scale, with the mold being shown engaging the plastics sheet ready for the container forming operation;

Figure 5 is a similar view with the upper mold assembly being shown in retracted position and illustrating the manner in which the partible mold releases a part formed in the plastics sheet;

Figure 6 is a fragmentary sectional elevational view showing the partible mold supporting links when the partible molds are engaging the plastics sheet; and

Figure 7 is a similar view illustrating another position of the same links.

Referring to the accompanying drawings, wherein is shown differential pressure forming apparatus of the nature of the machine shown

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in British Patent No. 1,029,895, entitled Differential Pressure Forming Machine, F generally designates the frame of the machine, which is shown as having side members 10 connected by an upper channel member 11. Mounted in fixed position on the upper frame 11 is a double-acting, fluid pressure operated cylinder 13 having a piston rod 14 (see Figure 2) which is coupled at its lower end, as at 15, to an upper platen frame generally designated 16. As shown, the platen frame member 16 may comprise end members 17 and 18 connected by side members 19 and 20. The members 17 and 18 are also braced by intermediate cross members 21 and 22. Mounted on the platen frame 16 is a female mold box assembly generally designated 23 which includes partible female mold or die members 24 which are supported in a manner which will be presently described.

A lower frame portion 12, see Figure 2, similarly supports a double-acting, fluid pressure operated cylinder 25 having a piston rod 26 which is coupled as at 27 to a lower platen assembly designated 28 which, as shown, may be formed similarly to the upper platen assembly 23. Clamp plates 29 secured by bolts 30, similar to those which secure the upper platen 16 to assembly 23, clamp a hollow male mold box assembly generally designated 31 to the end rails 32 and 33 of the lower platen assembly 28. As Figure 2 particularly indicates, the lower platen assembly 28 includes an air manifold or air box 34 having ports 35 therein which assist in the forming operation in the manner described in the aforementioned copending applications. An air line 36 may be provided in communication with a suitable source of air under pressure to provide air to the box 34 at the proper time. Also mounted by the air box 34 in vertical alignment with the female mold members 24 are plug assist members 37 which, in the usual manner, are employed to initially deform the heated plastics web P and facilitate its entry into the female mold members 24.

As in the aforementioned application, the forming machine illustrated employs toggle linkage systems for locking the upper and lower box assemblies 23 and 34 in molding or forming position and exerting a preloading stress thereon urging the mold assemblies 23 and 34 in a direction toward the plastics sheet P during the molding operation. Mounted on the upper frame member 11 are support blocks 38 in vertical alignment with support blocks 39 mounted on cross braces 40 provided on the upper platen assembly 20. A double-acting, fluid pressure operated cylinder 41 at each end of the upper platen 16 is supported at its outer end between the blocks 38 and 39 by pairs of straddling toggle links 42 and 43 which are pivotally connected to the cylinder 41 at their converging ends at 44 and are pivotally connected to the blocks 38 and 39, respectively, by pins 45 and 46. The piston rod 47 of each cylinder 41 connects with a block 48, and each block 48 is pivotally connected to toggle links 49 and 50 by a pivot pin 51. The lower platen assembly includes identical linkage mechanism and identical parts have been given the same numerals except that the numerals have been primed, and these parts accordingly need not and will not be independently described.

As Figures 4 and 5 indicate, each bell-shaped segmental mold 24 is mounted by the upper mold assembly 23 within an annular recess or socket 52, and spaced apart upper and lower ring members 53 and 54 are respectively bolted, as at 55 and 56, in position in each socket 52 around each partible mold 24. Each of the rings 53 and 54 includes an inwardly and upwardly tapering surface 53a and 54a, respectively, for a purpose which will presently be apparent, to cooperate with similarly inclined surfaces 57 and 58, respectively, provided on the four mating mold segments respectively designated 24a, 24b, 24c and 24d. When in closed position as shown in Figure 4, the segments 24a—24d provide a forming cavity *x* with a portion *y* of increased girth between its ends and it is only because the die segments 24a—24d are partible, as demonstrated in Figure 5, that a container C formed with a portion *z* of increased girth may be removed from the cavity *x*.

Each mold 24 is supported by a rod or shaft 59 which mounts a spider member 60 having a collar 60a' which is fixed to the shaft 59, the spider 60 having leg portions 60a, 60b, 60c and 60d with radially elongate slotted openings 61 provided therein to receive pins 62 which are anchored in each of the mold segments 24a—24d and have heads 62a of greater diameter than the width of slots 61. At their inner ends each of the mold segments 24a—24d are recessed as at 63 (see Figure 5) and include slot portions 63a to receive a retainer collar 64 which is bolted to the shaft 59 as at 65. In this way, the mold segments 24a—24d are mounted centrally on the shaft 59 but, as Figure 5 indicates, may be pivoted radially outwardly about their central connection to the retainer collar 64 because the pins 62 are permitted to move radailly within the confines of slots 61. In the closed position in which they are shown in Figure 4, the mold segments 24a—24d permit the formation of a container such as at C having an outwardly bulging wall projection *z*.

As in the machines illustrated in the aforementioned applications, suction forces are employed to draw the heated, deformable plastics sheet P into intimate contact with each mold cavity *x* formed by a set of mold or die sections 24a—24d, and vacuum ports such as shown at 67 which communicate with

the vacuum manifold 68 provided in the upper mold assembly 23 may be employed as shown in Figures 4 and 5. As Figure 2 indicates, a flexible hose member 69 may connect with the vacuum manifold 68 to communicate a vacuum pump with the mold cavity *x* at the appropriate time in the forming operation. It is also essential that the metal mold segments 24a—24d be cooled and, to accomplish this, each of the segments is provided with a pair of bored openings 70 which snugly accommodate an inlet coolant tube or pipe section 71 and an outlet coolant tube or pipe section 72. For each of the segments 24a—24d then, an inlet pipe portion 71 extends through an opening 73 provided in the wall 74 of the upper mold assembly 23 and extends through an opening 70 and down along the exterior wall of the mold segment. It is then connected with the upwardly extending outlet pipe portion 72 by a lateral connection portion 75, the portion 72 also extending upwardly in surface contact with the mold segment and through bore 70 therein out through the opening 73. It is to be understood that the line portions 71 may be connected with a source of circulating coolant, such as water, and that the line portions 72 may connect to a drain. It may, of course, be desirable to connect the water supply and return line portions 71 and 72 to a recirculating apparatus such as shown in the present assignee's United States patent No. 2,994,514.

The shafts 59 which support each segmental mold 24 are connected by bolts 76 to a plate 77, and coil springs 78 are provided on each shaft 59 between the plate 77 and the cover plate 79 of the upper mold assembly 23. The plate 77 is carried by linkage mechanism of the character disclosed in the aforementioned British Patent No. 1,029,895, which may comprise support frame members 80 which are suspended by means of toggle linkages generally indicated at 81 from support block members 82 which are fixed to the upper frame channel member 11. Each linkage 81 includes at its upper end a pair of links 83 which at their upper ends are connected by a pin 84 to one of the support blocks 82 and also includes a link 85 which is connected between links 83 by a pivot pin 86 and is connected at its lower end to the members 80 by a pivot pin 87.

The end 51a of toggle linkage pin 51 at one side of the machine extends inwardly into the path of a pair of spaced apart blocks 88 and 88a provided on a cross bar 89 which connects the front and rear sets of toggle linkages 81.

In operation, and when the upper and lower mold assemblies 23 and 31 are withdrawn from the plastics sheet P, the toggle links 83 and 85 are in the position in which they are shown in Figure 7. Then when a heated, deformable plastics sheet P is indexed to a position between the mold assemblies 23 and 31, cylinders 13 and 41 are operated in the first place to respectively move the platen 20 downwardly and expand links 49 and 50 from a contracted buckled position to the position in which they are shown in Figure 6. In this position the links 49 and 50 are in vertical alignment and the pin 51 is "on dead center" to lock mold 23 in a position in which a preloading force is exerted on the platen 20 urging it in a direction toward the plastic sheet P. This is the position in which the parts appear in Figure 4 and the mold segments 24a—24d are in the compressed position with the surfaces 57 and 58 in engagement with the surfaces 53a and 54a, respectively. To move the molds 24 as well as the sockets 52 into engagement with sheet P, the pin end 51a, while the mold assembly 23 is moving downwardly, moves from the position shown in Figure 7 to the position shown in Figure 6 and operates to expand links 83 and 85 to the vertically aligned position shown in Figure 1. In this position of the parts, the springs 78, as shown in Figure 4, are compressed.

The cylinders 25 and 41′ are then operated to move the lower mold assembly 31 upwardly to respectively engage the plastics sheet P and expand the links 49′ and 50′ until the pins 51 are "on dead center" and the linkage locks the mold assembly 31 in "up" position with a preloading force which urges the mold assembly 31 in a direction toward the plastic sheet P. The air pressure through line 36 and suction via line 69 are then applied in the manner fully described in the previously mentioned applications to move the portions of the plastic sheet P distended by the plug assists 37 into intimate engagement with the cavities *x* of the molds 24.

Thereafter, cylinders 13 and 41 are operated to respectively withdraw the mold assembly 23 and buckle the links 49 and 50. Initially, the pin end 51a simply moves in the space between abutment blocks 88 and 88a from the position shown in Figure 6 toward a position in which the pin end 51a engages the abutment block 88a, and during this time the molds 24 act as strippers and remain in engagement with the plastic web P as the sockets 52 move upwardly. At this time the mold segments 24a—24d are free of rings 53 and 54 and free to radially expand. When the pin end 51a does contact the abutment 88a and buckles the links 83 and 85 so that the pins 86 move out of "dead center" position, the compressed springs 78 are free to move the mold segments 24a—24d upwardly into the sockets 52 as the upper mold assembly continues to rise and at this time, as shown in Figure 5, the bulged portions *z* of each container C formed "cams" the mold segments 24a—24d outwardly to permit them to clear the container C and withdraw past the bulged portion *z* thereof. In Figure 5 the mold segments 24a—24d are shown in the process of being moved back into

the sockets 52.

The cylinders 25 and 41' are also operated at about this time to respectively withdraw the mold assembly 31 and buckle the links 49' and 50'. In machines of this type the plastics sheet P is conveyed to a position between the upper and lower mold assemblies by the usual advancing chain mechanism A described in British Patent No. 1,029,895 and plastics sheet edge guides G may be employed to prevent the sheet P from moving upwardly when the segmental molds 24 are snapped upwardly.

WHAT WE CLAIM IS:—

1. In a differential pressure forming machine particularly for forming articles such as containers: female mold assembly means; cavity forming female mold means carried by said female mold assembly means; axially opposed mold means; means for advancing a sheet of hot deformable plastics between said female mold means an opposed mold means; means mounting said female mold assembly means and female mold means for relative axial travel; means for moving said female mold assembly means and thereby said female mold means toward said opposed mold means; means for producing a differential pressure on opposite sides of said plastics sheet and causing a portion of said sheet to be formed to the shape of said female mold means; means for moving said female mold assembly means away from said opposed mold means; and means holding said female mold means in engagement with said sheet, when the female mold assembly means is withdrawn following formation of the shape in said female mold means, for a predetermined interval to operate to strip the sheet from the withdrawing female mold assembly means.

2. A differential pressure forming machine as set forth in claim 1 wherein said female mold means is partible and said holding means comprises: means holding said partible mold means in radially closed position when the female mold assembly means is in engagement with said plastics sheet, and permitting radial expansion thereof when the female mold assembly means is withdrawn thereby permitting the formed article to be released.

3. A differential pressure forming machine as set forth in claim 2 further comprising: means responsive to movement of said female mold assembly means for automatically closing said partible female mold means after said partible female mold means is opened to release said article.

4. A differential pressure forming machine as set forth in either one of claims 2 and 3 wherein said means holding said partible female mold means includes pivot means for enabling said female mold means to pivot thereon when said female assembly is withdrawn.

5. A differential pressure forming machine as set forth in claim 4 wherein said female mold means comprises a plurality of partible die segments each having a radial wall portion permitting them collectively to form a closed end cavity, each of said wall portions having first and second radially spaced apart mounting and guide means connecting each of said partible die segments with said pivot means.

6. A differential pressure forming machine as set forth in any of claims 1—5 and including means conditioned by withdrawal of said female mold assembly means for moving said female mold means back into engagement with said holding means upon further withdrawal of same female mold assembly means in the same direction.

7. A differential pressure forming machine as set forth in claim 1 wherein said female mold means includes partible female mold segments; and means mounting said segments to swing radially.

8. A differential pressure forming machine as set forth in claim 1 wherein said female mold assembly means includes socket means and said female mold means includes partible female mold segments received in said socket means; means mounting said segments for radial movement from a closed mated postiion, in which they form a mold cavity for forming an article, to a radially expanded position; co-operating means on said socket means and mold segments for moving said segments to closed position when the socket means and mold segments are moved relatively axially; each of said segments having radial wall portions permitting them to form a closed end cavity; means mounting said radial wall portions for pivotal movement; and radially extending slot and axially extending guide means associated with each of said wall portions to guide said segments as they swing radially.

9. A differential pressure forming machine as set forth in claim 1 wherein said female mold means includes partible female mold segments; means mounting said segments for radial movement from a closed mated position in which they form a mold cavity for forming an article to a radially expanded position; said mold assembly means including a spider means having radially extending slots; each of said segments having mounting means mounted for pivotal movement in said slots.

10. A differential pressure forming machine as set forth in claim 9 in which said spider means is mounted on an actuator rod supported for axial movement in said mold assembly means; and axially spaced apart, mating, tapered surfaces on said mold assembly means and segments co-operating to pivot said segments to closed position.

11. A differential pressure forming machine as set forth in any of claims 7—10 wherein said female mold means includes generally U-

shaped coolant circulating tube means having an inlet length extending along each segment and an outlet length extending in the opposite direction along each segment.

12. A differential pressure forming machine as set forth in claim 7 wherein said means for automatically closing said female mold means includes resilient means for biasing said female mold means against movement relative to said mold assembly means.

13. A differential pressure forming machine substantially as described and/or as illustrated in the accompanying drawings.

14. A container or like article formed of thermoplastic material when made by the means claimed in any one or more of the preceding claims.

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1205694 COMPLETE SPECIFICATION
5 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 1

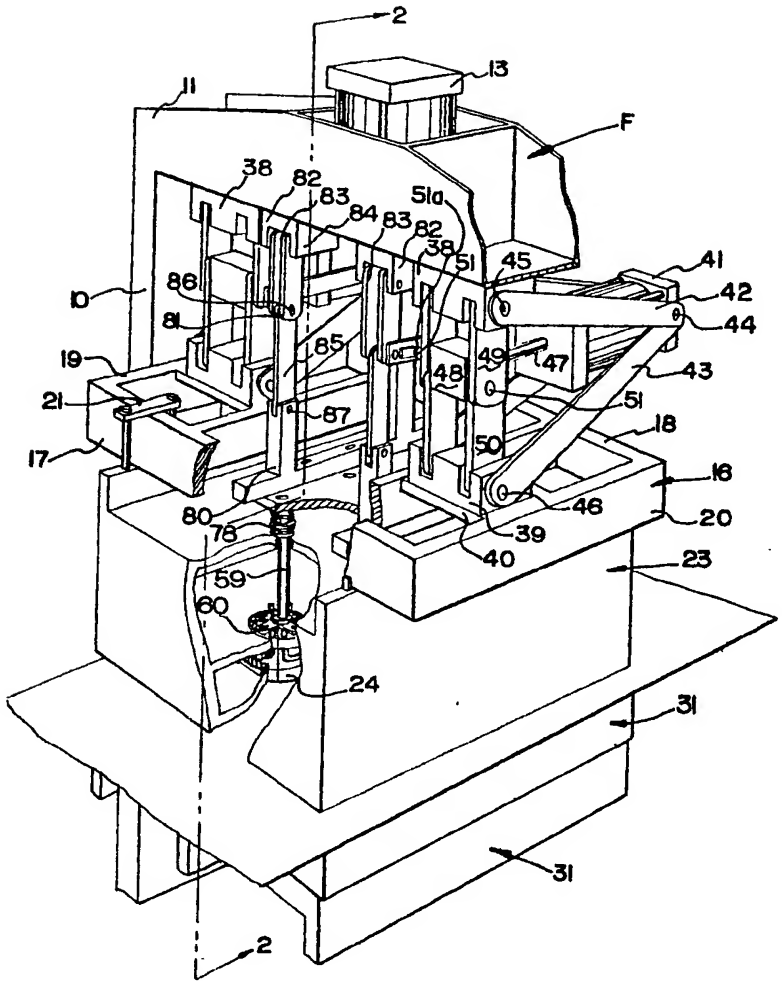

FIG 1

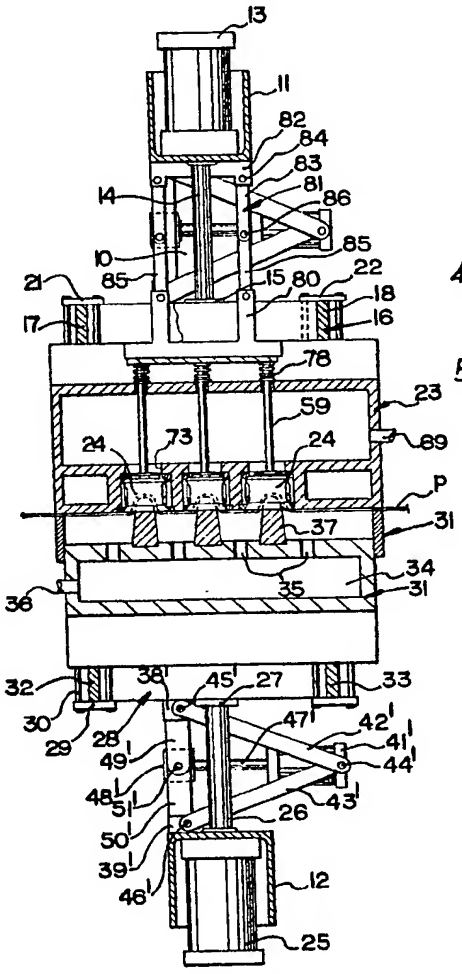

FIG 2

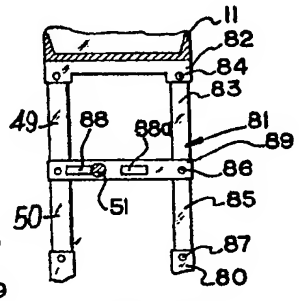

FIG 6

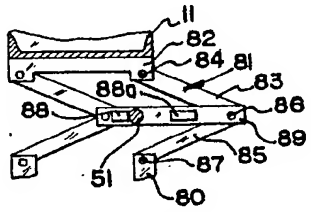

FIG 7

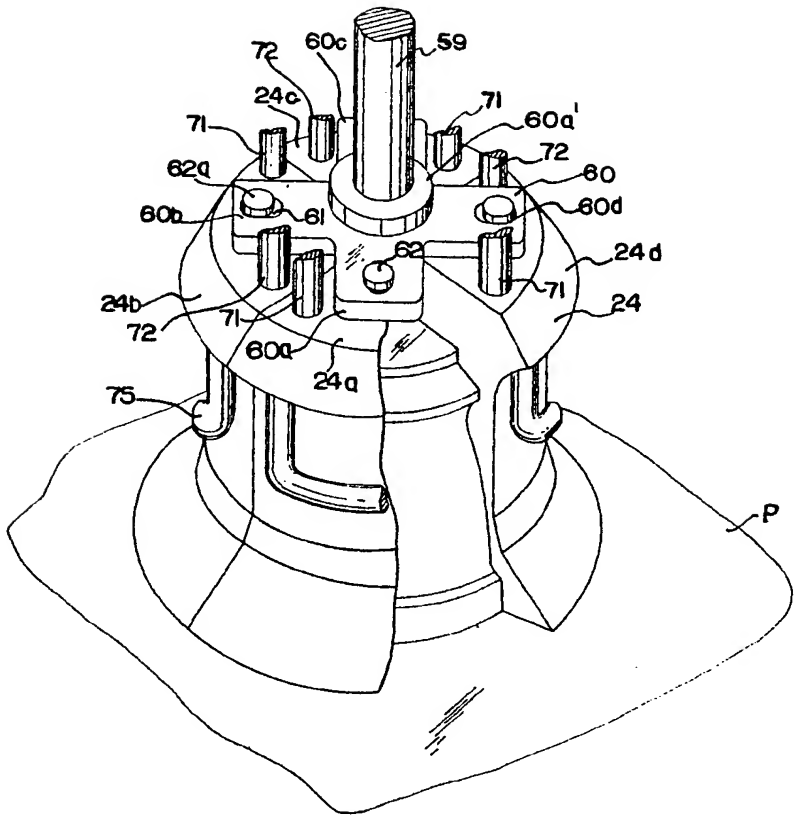

FIG 3

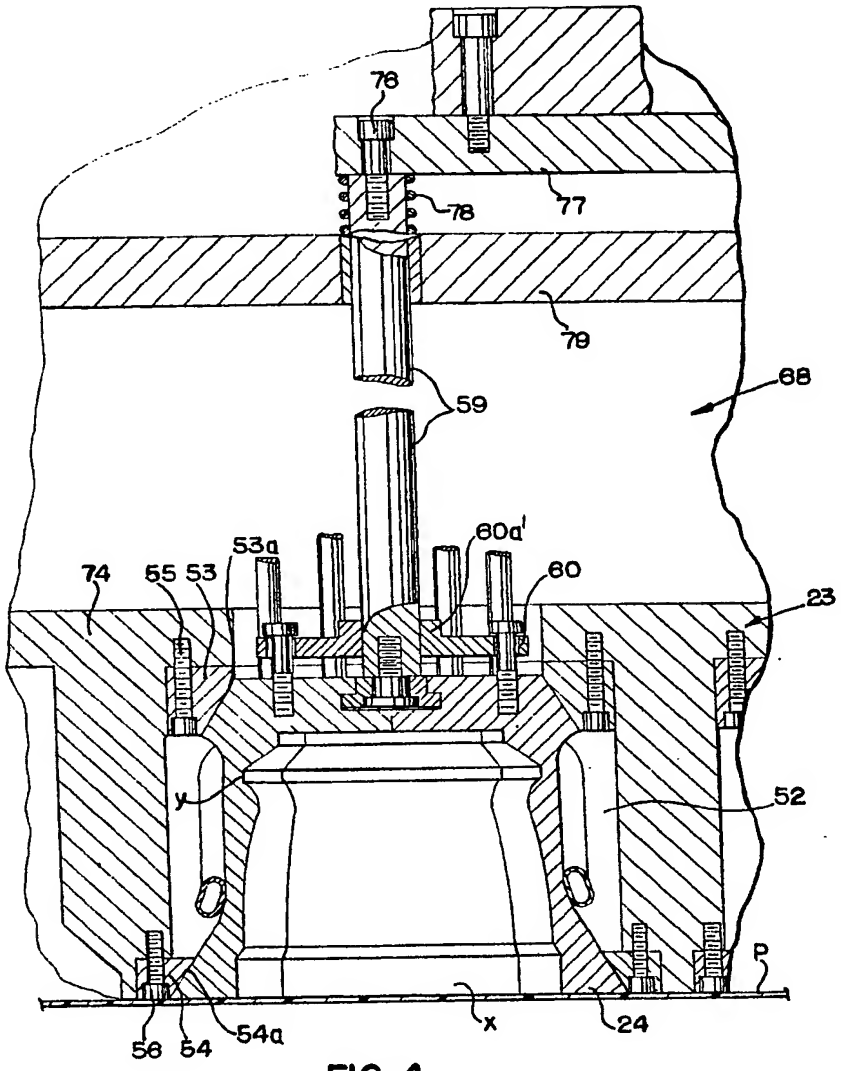

FIG 4

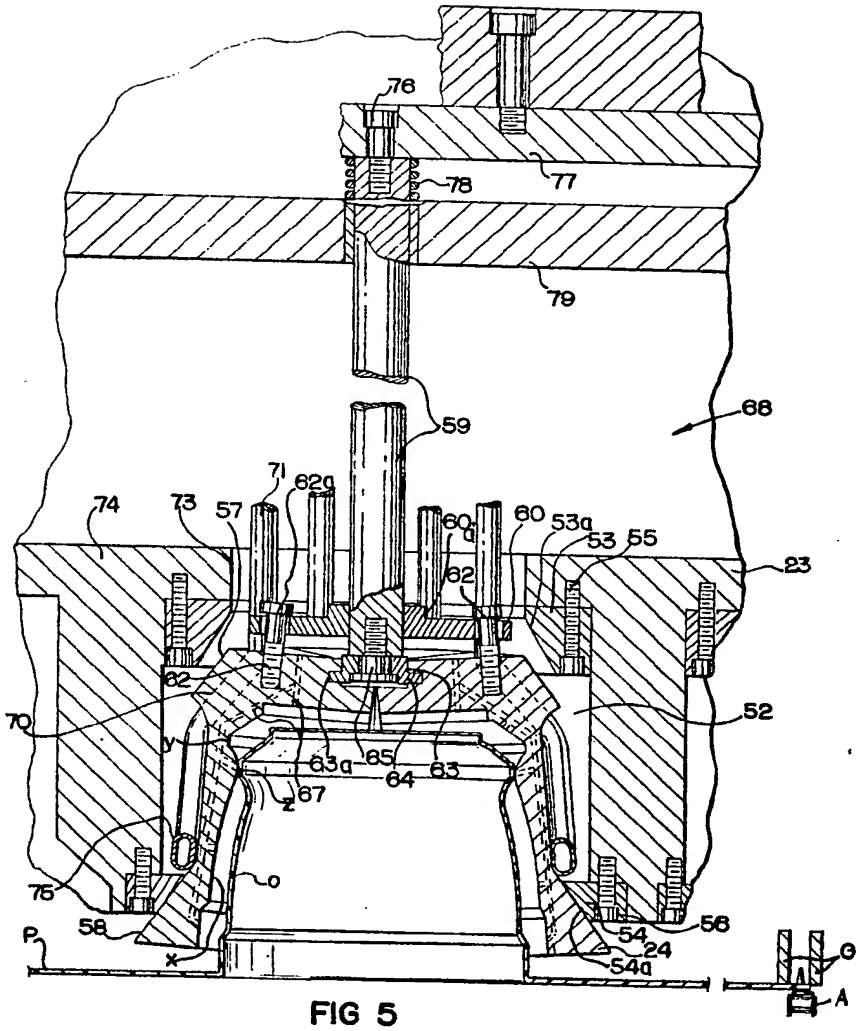

FIG 5